UNIVERSITY OF ILLINOIS

Agricultural Experiment Station.

URBANA, DECEMBER, 1902.

BULLETIN NO. 82.

METHODS OF CORN BREEDING.*

By Cyril George Hopkins, Ph. D., Professor of Agronomy in the Agricultural College and Chief in Agronomy and Chemistry in the Agricultural Experiment Station.

It is a well established fact that there now exist markets and demands for different kinds of corn.

The price of corn varies, say, from ½ cent to 1 cent per pound.

The cost of protein in the principal stock feeding states varies from 3 to 5 cents per pound. In other words, the protein is several times more valuable per pound than corn itself. Consequently, stock feeders want more protein in corn. (Very possibly the feeders in the southern states want more carbohydrates to supplement their present more abundant supplies of nitrogenous food stuffs.)

The price of corn starch varies from 2 or 3 cents to 5 or even 10 cents per pound, depending upon the wholesale or retail nature of the sale. The manufacturers of starch and of glucose sugar, glucose-syrup, and other products made from starch want more starch in corn.

*Read before the Section on Agriculture and Chemistry of the Association of American Agricultural Colleges and Experiment Stations, at Atlanta, Georgia, October 8, 1902; and before the Illinois Live Stock Breeders' Association, at Bloomington, Illinois, November 20, 1902.

In its own publication a large commercial concern, which uses enormous quantities of corn, makes the following statements:

"A bushel of ordinary corn, weighing 56 pounds, contains about 4½ pounds of germ, 36 pounds of dry starch, 7 pounds of gluten, and five pounds of bran or hull, the balance in weight being made up of water, soluble matter, etc. The value of the germ lies in the fact that it contains over 40 per cent. of corn oil, worth, say, 5 cents per pound, while the starch is worth 1½ cents, the gluten 1 cent, and the hull about ½ cent per pound.

"It can readily be seen that a variety of corn containing, say one pound more oil per bushel would be in large demand.

"Farmers throughout the country do well to communicate with their respective agricultural experiment stations and secure their coöperation along these lines."

These are statements and suggestions which should, and do, attract the attention of experiment station men. They are made by the Glucose Sugar Refining Company of Chicago, a company which purchases and uses, in its six factories, about fifty million bushels of corn annually. According to these statements, if the oil of corn could be increased one pound per bushel, the actual value of the corn for glucose factories would be increased 5 cents per bushel; and the President of the Glucose Sugar Refining Company has personally assured the writer that his company would be glad to pay a higher price for high oil corn whenever it can be furnished in large quantities. The increase of five cents per bushel on fifty million bushels would add $2,500,000 to the value of the corn purchased by this one company each year. The Glucose factories are now extracting the oil from all the corn they use and are unable to supply the market demand for corn oil. On the other hand, to these manufacturers, protein is a cheap by-product and consequently they want less protein in corn.

Corn with a lower oil content is desired as a feed for bacon hogs, especially for our export trade, very extensive and thorough investigations conducted in Germany and Canada having proved conclusively that ordinary corn contains too much oil for the production of the hard firm bacon which is demanded in the markets of Great Britain and Continental Europe.

The methods of corn breeding devised by the Illinois Experiment Station and now used not only by us, but also by the Illinois Seed Corn Breeders' Association, and, to some extent, by other Experiment Stations and other corn breeders, have for their object the improvement of corn—in yield and in quality. In the main the methods are now the same as we have employed for the past six

years and they have given results which enable us to assert with confidence that by these methods corn can be improved in a very marked degree and for many different purposes. The yield of corn can be increased, and the chemical composition of the kernel can be changed as may be desired, either to increase or to decrease the protein, the oil, or the starch.

Following is a brief description of the methods of corn breeding which we practice and which we have recommended to others:

Physical Selection of Seed Corn.

The most perfect ears obtainable of the variety of corn which it is desired to breed should be selected. These ears should conform to the desirable standards of this variety and should possess the principal properties which belong to perfect ears of corn, so far as they are known and as completely as it is possible to secure them. These physical characteristics and properties include the length, circumference, and shape of the ear and of the cob; the number of rows of kernels and the number of kernels in the row; the weight and color of the grain and of the cob; and the size and shape of the kernels. In making this selection the breeder may have in his mind a perfect ear of corn and make the physical selection of seed ears by simple inspection, or he may make absolute counts and measurements and reduce the physical selection almost to an exact or mathematical basis.

In this connection let me suggest that there is some danger of corn breeders making too much of what might be called fancy points in selecting seed ears. We should learn the facts which are facts and not base our selections too much upon mere ideas and opinions. For example, it is not known that ears whose tips are well filled and capped with kernels are the best seed ears. Indeed it is not improbable that the selection of such seed ears will cause the production of shorter ears and a reduced yield per acre. It is true that the percentage of shelled corn from a given ear is the greater, the greater the proportion of corn to the cob, but our interest in that percentage is very slight compared to that of yield per acre, and perhaps for the greatest possible yield of shelled corn per acre it requires that the ears shall have good sized cobs. Possibly the corn which shall untimately surpass all others for yield per acre will have tapering and not cylindrical ears. These are some of the points regarding which men have some ideas and opinions but as yet we have no definite facts, and we shall need several years more to obtain absolute knowledge regarding some of these points. Let us base our selections of seed corn first upon

known facts and performance records, and secondly upon what one may call his "type" of corn.

Chemical Selection By Mechanical Examination.

The selection of seed ears for improved chemical composition by mechanical examination of the kernels is not only of much assistance to the chemist in enabling him to reduce greatly the chemical work involved in seed corn selection, but it is of the greatest practical value to the ordinary seed corn grower who is trying to improve his seed corn with very limited service, if any, from the analytical chemist. This chemical selection of seed ears by mechanical examination, as well as by chemical analysis (which is described below), is based upon two facts:

1. That the ear of corn is approximately uniform throughout in the chemical composition of its kernels.

2. That there is a wide variation in the chemical composition of different ears, even of the same variety of corn. These two facts are well illustrated in Table 1.

Table I. Protein in Single Kernels.

	Ear A, protein, per cent.	Ear B, protein, per cent.	Ear C, protein, per cent.	Ear D, protein, per cent.
Kernel No. 1	12.46	11.53	7.45	8.72
Kernel No. 2	12.54	12.32	7.54	8.41
Kernel No. 3	12.44	12.19	7.69	8.73
Kernel No. 4	12.50	12.54	7.47	8.31
Kernel No. 5	12.30	12.14	7.74	8.02
Kernel No. 6	12.49	12.95	8.70	8.76
Kernel No. 7	12.50	12.84	8.46	8.89
Kernel No. 8	12.14	*	8.69	9.02
Kernel No. 9	12.14	12.04	8.86	8.96
Kernel No. 10	12.71	12.75	8.10	8.89

It will be observed that, while there are, of course, small differences among the different kernels of the same ear, yet each ear has an individuality as a whole, the difference in composition between different ears being much more marked than between different kernels of the same ear.

The uniformity of the individual ear makes it possible to estimate or to determine the composition of the corn by the examination or analysis of a few kernels. The remainder of the kernels on the ear may then be planted if desired. The wide variation in the composition between different ears furnishes a starting point for the selection of seed in any of the several different lines of desired improvement.

The methods of making a chemical selection of ears of seed

*Determination lost by accident.

HIGH-PROTEIN KERNELS (little starch)

LOW-PROTEIN KERNELS (much starch)

PLATE I.

corn by a simple mechanical examination of the kernels is based upon the fact that the kernel of corn is not homogenous in structure, but consists of several distinct and readily observable parts of markedly different chemical composition. (See illustrations.) Aside from the hull which surrounds the kernel, there are three principal parts in a grain of corn:

1. The darker colored and rather hard and horny layer lying next to the hull, principally in the edges and toward the tip end of the kernel, where it is about 3 millimeters, or ⅛ of an inch, in thickness.

2. The white, starchy-appearing part occupying the crown end of the kernel and usually also immediately surrounding, or partially surrounding, the germ.

HIGH-OIL KERNELS (large germs)

LOW-OIL KERNELS (small germs)

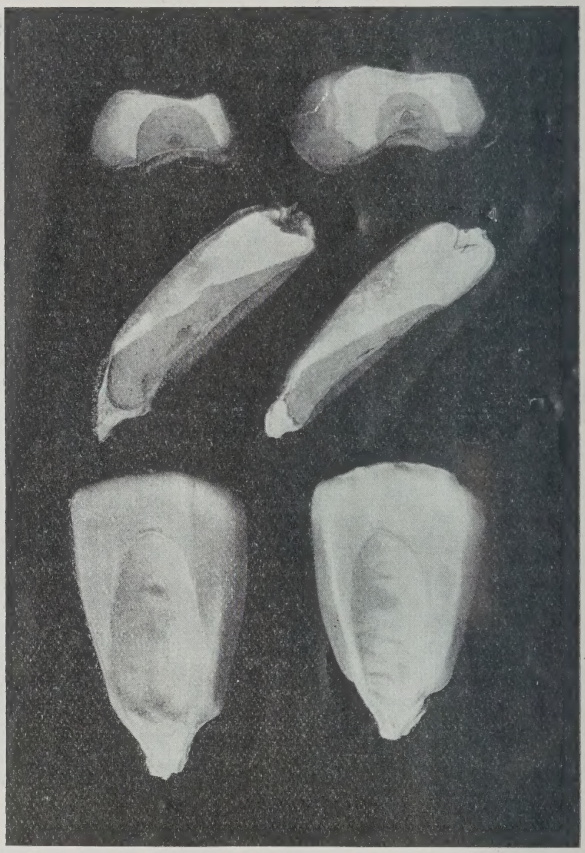

PLATE 2.

3. The germ itself which occupies the central part of the kernel toward the tip end.

These different parts of the corn kernel can be readily recognized by merely dissecting a single kernel with a pocket knife, and it may be added that this is the only instrument needed by anybody in making a chemical selection of seed corn by mechanical examination.

The horny layer which usually constitutes about 65 per cent. of the corn kernel contains a large proportion of the total protein in the kernel.

The white, starchy part constitutes about 20 per cent. of the

whole kernel, and contains a small proportion of the total protein. The germ constitutes only about 10 per cent. of the corn kernel, but, while it is rich in protein, it also contains more than 85 per cent. of the total oil content of the whole kernel, the remainder of the oil being distributed in all of the other parts.

By keeping in mind that the horny layer is large in proportion and also quite rich in protein and that the germ, although rather small in proportion is very rich in protein, so that these two parts contain a very large proportion of the total protein in the corn kernel, it will be readily seen that by selecting ears whose kernels contain more than the average proportion of germ and horny layer we are really selecting ears which are above the average in their protein content. As a matter of fact, the method is even more simple than this, because the white starchy part is approximately the complement of, and varies inversely as, the sum of the other constituents; and to pick out seed corn of high protein content it is only neccessary to select those ears whose kernels show a relatively small proportion of the white, starchy part surrounding the germ.

As more than 85 per cent. of the oil in the kernel is contained in the germ, it follows that ears of corn are relatively high or low in their oil content, according as their kernels have a larger or smaller proportion of germ.

In selecting seed corn by mechanical examination for improvement in composition we remove from the ear a few average kernels; cut two or three of these kernels into cross sections and two or three other kernels into longitudinal sections and examine these sections as they are cut, usually simply with the naked eye.

If we are selecting seed ears for high protein content we save those ears whose kernels show a small proportion of the white starch immediately adjoining or surrounding the germ. If selecting corn for low protein content we look for a larger proportion of white starch surrounding the germ. Our results have shown that the white starch in this position, that is, surrounding the germ toward the tip end of the kernel, is a better index of the protein content than the starch in the crown end.

If we are selecting seed ears for high oil content we save those ears whose kernels show a large proportion of firm and solid germ; while if seed of low oil content is desired, we look for a small proportion of germ in the kernel.

It should be emphasized that it is not the absolute, but proportionate, size or quantity of germ or of white starch which serves as a guide in making these selections.

Chemical Selection by Chemical Analysis.

In selecting seed corn by chemical analysis we remove from the individual ear two adjacent rows of kernels as a representative sample. This sample is ground and analyzed as completely as may be necessary to enable us to decide whether the ear is suitable for seed for the particular kind of corn which it is desired to breed. Dry matter is always determined in order to reduce all other determinations to the strictly uniform and comparable water-free basis. If, for example, we desire to change only the protein content, then protein is determined. If we are breeding to change both the protein and the oil, then determinations of both of these constituents must be made.

For a satisfactory breeding plot, about 20 to 40 selected seed ears are required. If the breeder desires to make only physical improvement then he should select, say, 40 of the most nearly perfect ears which it is possible to pick out by inspection or by exact physical measurements. If it is desired to improve the composition or quality of the corn as well as the physical properties, then at least 200 physically perfect ears should be selected, and, from these 200 ears, the 40 ears which are most suitable as seed for the particular kind of corn which it is desired to breed should be selected, either by mechanical examination of sections of kernels, which anybody can make, or by chemical analysis, or by a combination of these two methods. In our own work we now commonly select by physical inspection or measurement the 200 ears; then, from these 200 ears, we select by mechanical examination of sections of kernels the best 50 or 100 ears, and from this lot we finally select by chemical analysis the best 20 to 40 seed ears for planting. This combination of methods effects a very satisfactory seed selection and requires only one-half as much chemical work as would be required if the method of chemical analysis alone were employed.

Table 2 shows very fairly the degree of seed improvement which may be accomplished by these different methods of selection, when breeding to change only the protein content of corn.

It may be stated that equally satisfactory results may be obtained in chemical selection by mechanical examination for securing seed ears of high or low oil content. For example, the writer has selected by mechanical examination, from a lot of 272 ears of corn, 18 ears for high oil content which averaged 5.24 per cent. of oil; and, from the same lot of corn, 30 ears were selected for low oil content which averaged 4.13 per cent. oil, making an average difference of 1.11 per cent. of oil.

TABLE 2. SOME FAIR ILLUSTRATIONS OF ACTUAL RESULTS OBTAINED IN SELECTION OF SEED CORN.
(Protein, average per cent.)

Variety	200 average seed ears.	50 ears selected by mechanical examination.	28 ears selected by chemical analysis.	10 best seed ears.	Best single seed ear.
Silver Mine.....	10.00	9.47	8.77	7.97	7.00
Boon County White..	10.57	9.72	9.36	8.84	8.69
Leaming.....	11.96	11.36	10.79	10.08	8.82
Leaming	11.96	12.44	13.33	14.03	14.63
Leaming.....	11.27	11.84	12.43	13.12	14.71
Yellow Dent.....	11.14	11.64	12.11	12.55	13.24
Riley's Favorite.....	11.02	11.38	12.41	12.99	15.78
Burr's White.....	12.48*	12.88	14.36	14.87	15.71
Burr's White.....	9.20†	9.10	7.77	7.56	7.08
Leaming.....	11.26	12.14‡			
Leaming.....	11.26	10.67‡			

* Average protein content of ten field rows of Burr's White after four years' breeding for high protein.

† Originally from same stock of Burr's White as preceding, but bred four years for low protein.

‡ Two lots of 42 ears each selected from the same lot of 200 ears for two breeding plots, high protein and low protein, the seed for which is selected by physical inspection and mechanical examination but without chemical analysis of individual ears.

If the method of mechanical examination alone is employed in making the chemical selection, then, if possible, there should be some chemical control of the work, at least until the breeder has become sufficiently skilled, or has had sufficient experience, to feel that he knows how to make a chemical selection of seed ears by mechanical examination of kernels. Such a chemical control does not involve a large amount of chemical work. In Illinois the Experiment Station offers such a chemical control to farmers who will agree to make the selection of the best possible seed, both by physical inspection of ears and mechanical examination of kernels and who will further agree to secure data and breed the corn in accordance with our directions.

This control is affected by analyzing only two samples of corn each year; one composite sample of the rejected ears, five average kernels being taken from each ear, and one composite sample of the 20 to 40 selected seed ears, twenty average kernels being taken from each of these ears, and each of these two composite samples being properly labeled and analyzed.

One of the best selections which has yet been made by mechanical examination was accomplished last spring by a farmer who is breeding corn for higher protein content. Out of a lot of 165 ears

of corn he selected 15 ears whose protein content averaged 1.48 per cent. higher than that of the 150 rejected ears, as was determined by the chemical analysis of a composite sample from each of the two lots. Because of the chemical control which the Station affords him, he knows each year just how much he has accomplished.

If the purpose of breeding a kind of corn is principally to change its content of a single constituent, as to increase protein, then the selection of the best 40 ears is simple and regular by either method; but if it is desired to effect changes in the content of two constituents, as to increase the protein and to increase the oil in the same corn, then one could hardly expect to make much progress in both directions, if he relied solely upon mechanical examination of kernels for chemical selection of seed ears. Even after the chemical analyses of 100 ears have been made it requires some computation to determine which are really the best 40 ears. For example, an ear may be desirable for seed because of its high protein content, but it may not be sufficiently high in oil. In order to reduce the selection to an exact basis, we have adopted simple mathematical computations for all such cases.

For high protein and high oil in the same corn, we multiply the percentage of protein by the percentage of oil and use the product as the selection coefficient, the forty highest products designating the forty best ears.

For low protein and low oil we multiply the percentages together and use the lowest product as the selection coefficient.

For high protein and low oil in the same corn, we divide the percentage of protein by the percentage of oil and use the highest quotients as our selection coefficients.

TABLE 3. SELECTION OF SEED CORN FOR HIGH PROTEIN AND HIGH OIL.

No. Ear	Protein in corn.	Oil in corn.	Selection coefficient.
1	11.17	6.03	**67.30**
2	12.66	4.90	62.00
3	13.60	4.92	**66.89**
4	10.85	4.55	49.89
5	11.01	5.72	**62.97**
6	11.50	4.77	54.81
7	14.71	5.56	**81.75**
8	10.07	4.73	47.62
9	13.14	5.44	**71.53**
10	10.19	5.80	59.10
11	11.01	5.97	**65.78**
12	10.39	4.73	49.13
13	13.96	5.28	**73.72**
Average	11.87	5.26	62.50

For low protein and high oil we divide in the same manner, but use the lowest quotients for selecting the best ears.

Table 3 illustrates the value of this method as applied to the selection of the best seed ears for both high protein and high oil.

It will be observed that some ears which are high in only one desirable constituent (see No. 2 and No. 10) must be discarded because the selection coefficients which they give are even below the average; while other ears which may be quite low in one constituent (see No. 1 and No. 3) still furnish acceptable selection coefficients.

The Breeding Plot.

The 40 selected seed ears are planted in 40 separate parallel rows, one ear to a row, consequently the breeding plot should be at least 40 corn rows wide and long enough to require about three-fourths of an ear to plant a row. It is well to shell the remainder of the corn from all of the 40 ears, mix it together, and use it to plant a border several rows wide entirely around the breeding plot, to protect it, especially from foreign pollen.

In my judgement one of the most practical and satisfactory locations for the breeding plot is in a larger field of corn planted with seed which is as nearly as possible of the same breeding as that planted in the breeding plot itself. The stock seed for this field should always be selected from the previous year's breeding plot and it may well include as many of the 160 rejected ears as are known to be above the average of the 200. Or, if the breeding plot can be well isolated from all other corn fields and still occupy good soil, this also makes a very suitable location for it.

The very best ears of seed corn are planted in the center rows of the breeding plot, the remainder of the ears being planted in approximately uniform gradation to either side, so that the least desirable ears among the 40 are planted in the outside rows; and in the final selection of the best field rows from which the next year's seed ears are to be taken, some preference is given to the rows near the center of the plot.

While we are not yet ready to make absolute statements regarding the matter, nevertheless, from the data which we have secured, and are securing upon the subject, we now recommend that every alternate row of corn in the breeding plot be completely detasseled before the pollen matures and that all of the seed corn to be taken from the plot be selected from these 20 detasseled rows. This method absolutely prohibits self-pollenation or close-pollenation of the future seed. By self-pollenation is meant the transfer of pollen from the male flower of a given plant to the fe-

male flower of the same plant; and by close-pollenation is meant the transfer of pollen from the male flower of one plant to the female flower of another plant in the same row, both of which grew from kernels from the same seed ear.

The transfer of pollen from one plant to another plant which grew from kernels from a different seed ear, we term cross-pollenation. We have been for several years accumulating data which show that *artificial* self-pollenation is very injurious to the vitality and vigor of the seed produced, and we have also secured data pointing toward an injurious effect of close-pollenation even by natural methods, so that we feel justified in recommending, at least tentatively, the use of cross-pollenation in seed corn breeding.

It is also recommended that in the 20 rows of corn which are not detasseled no plants which appear imperfect, dwarfed, immature, barren, or otherwise undesirable, should be allowed to mature pollen. Detasseling is accomplished by going over the rows two or three times and carefully pulling out the tassels as they appear.

Occasionally an entire row is detasseled because of the general inferiority of the row as a whole.

Field Selections Based on Performance Records.

As the corn crop approaches maturity we are then ready for the first time to begin at the real beginning in the selection of seed corn; that is, with the whole corn crop and the whole corn plant, as it stands in the field.

We then make our first selection of seed corn from the field rows (each of which is the progeny of a separate single ear) on the basis of peformance record. Each of the twenty detasseled rows is carefully examined. Some of them are discarded for seed purposes by simple inspection, and with some rows this decision may be made early in the growing season; because, when each field row is planted from a separate individual ear, that row has an individuality which in many cases is very marked. It may show very imperfect germination (in the most careful work the germinating power of each ear is ascertained before planting), it may be of slow growth, produce small weak plants, or numerous barren stalks. The plants may be tall and slender or very thick and short. In one row the ears may be borne high on the stalks, while in the adjoining row they may average one or two feet nearer the ground. One row may yield more than twice as much corn as an adjoining row on the same kind of soil. As a matter of fact, when one begins to breed corn by the row system (one seed ear to each row), he is usually surprised to find that the plants in some

rows are so very different from those in others, as will be seen from data from one of our 1901 breeding plots, which are given in Table 4.

TABLE 4. PERFORMANCE RECORD OF BREEDING PLOT, 1901. (Breeding for high protein).

Field Row No.	Protein in seed ear.	Weight of ear corn in crop.
1	12.06	91.0
2	12.17	86.0
3	12.19	98.5
4	12.26	99.5
5	12.31	77.0
6	12.40	**118.0**
7	12.66	**116.0**
8	12.83	54.5
9	12.90	**107.0**
10	15.78	**103.0**
11	12.93	87.0
12	12.90	**127.5**
13	12.72	**113.0**
14	12.45	**123.5**
15	12.32	**103.5**
16	12.31	92.0
17	12.23	85.5
18	12.18	**117.0**
19	12.07	**140.5**
20	12.06	97.0
Average	12.59	101.9

We take no seed corn from a row which produces a large proportion of imperfect plants, barren stalks, small ears or a low yield, even though a few apparently good seed ears might be found in the crop which that row yields.

The points to be considered in the selection of the field rows, and finally in the individual plants from which seed ears may be taken should include the per cent. of "stand" of plants, the height and physical proportions of the plant, the character and amount of foliage, the position of the ear on the stalk, the length and size of the ear shank, the per cent. of ear-bearing plants, the time of maturity, the total yield of the row, the average weight of the ears, and the number of good seed ears which the row produces.

Some of these points can be determined by inspection; some require actual counts and measurements or weights.

The corn from each of the detasseled rows which have not been rejected by inspection is now harvested. First, all of the ears on a row which appear to be good ears and which are borne on good plants in a good position and with good ear shanks and husks are harvested, placed in a bag with the number of the row, and finally weighed together with the remainder of the crop from

the same row. The total weight of ear corn which the row yields is the primary factor in determining the 10 best rows from which all of the 200 ears for the next year's selection must be taken; and yet no corn breeder should follow even this rule absolutely or blindly. If it should happen that one of these ten best yielding rows, although slightly higher in yield, is nevertheless plainly inferior to some other row in the number of good ears produced, the row selection should be changed accordingly. Yield is of first importance, but it should not exclude all other points. It is more practical and profitable to produce 99 pounds of good ears than 100 pounds of nubbins. Other things being equal, or nearly so, preference is also given to the rows nearest the center of the field, for reasons already explained and well illustrated in Table 4.

In the final selection of the 40 seed ears we prefer to have as many as possible of the ten best field rows represented, and we frequently sacrifice slight advantages in chemical composition for the sake of having such a large representation, because of the possible future evil effects of too close in-breeding.

Each lot of 20 ears (more or less) from each of the ten best rows and finally each single ear of the 40 seed ears ultimately selected is kept labeled, and permanent records are made of the number and the description of the ear, the composition of the grain, performance record of the row, etc., so that as the breeding is continued an absolute pedigree is established, on the female side, for every ear of corn which may be produced from this seed so long as the records are made and preserved. We also know absolutely that we have good breeding on the male side although the exact individual pedigrees of the males cannot be known and recorded. The corn which we first began to breed (see bulletin No. 55, Illinois Experiment Station) we are this season growing in five different breeding plots in Illinois, and it is now being grown in two or three other states; and every ear which is grown this year in any of those breeding plots has an established and recorded pedigree for seven generations. For example, each of the ears of corn which was grown the past season in our high protein breeding plot has a recorded pedigree showing the protein content of its dam, of its grand dam, of its great, grand dam, of its great, great, grand dam, of its great, great, great, grand dam, and its great, great, great, great, grand dam.

In conclusion let me say that, to the practical corn breeder, I would urge only three things:

First: Adopt the row system, plant 20 to 40 good seed ears,

one ear to a row; then select your seed for the next year, on the basis of performance record, from about 10 rows which produce the highest yield and the best ears.

Second: Breed corn for a purpose. If you wish to feed corn, breed and grow high protein corn. If you wish to grow corn for the starch and glucose factories, breed and grow corn the factory wants.

Third: Until we have facts, don't devote too much time to "fancy points," such as trying to produce kernels on the tip end of the cob, or trying to reduce the size of the cob, or trying to make the tip end of the ear as large as the butt, or pulling out suckers, or doing other things the ultimate effect of which is unknown. It is not yet known with any degree of certainty whether such things are beneficial, injurious, or without effect, on the production of the crop.

And don't feel that you can't breed corn even if you are unable to detassel barren stalks. Last year we had fields with 50 per cent. of barren stalks,—this year in some fields from that seed we have about five-tenths of one per cent. of barren stalks, and these examples fairly illustrate the tremenduous effect of soil and season and condition of growth, as compared with breeding, upon the production of barren stalks. Barren stalks bear no ears, and the whole tendency of Nature's Law is to breed them out, and even without the intervention of man. As a matter of fact, in order to give to barren stalks an equal chance with ear-bearing plants to propagate themselves, we should be obliged to detassel every ear-bearing plant in the field. In studying this problem it should be borne in mind that the female parent of the barren stalk was not barren.

It is probably much more important that we absolutely prevent self-pollenation and close-pollenation by detasseling alternate rows, but even this practice is still an experiment. It is very true that exceedingly poor corn has been produced by artificial or *hand* self-pollenation but recent experiments have also shown that corn may be degenerated by artificial cross-pollenation; and it should be understood that our recommendation to detassel alternate rows in the breeding plot is tentative, and I certainly would not urge this practice. Probably such detasseling will prove somewhat helpful to the corn breeder, but we know that very great improvement can be made without detasseling at all, simply by selecting seed on the basis of performance record and for desirable quality or composition.

3 0112 099150358